Characteristics of plasma motions in the surge are determined with the normalizing radial gradient filter and the Fourier motion filter. The shape of the surge is found to change from a `C' shape to an inverse `C' shape after a formation of a cusp, a signature of reconnection. There are apparent upflows seen above the cusp top and downflows below it. The upflows show rising and rotational motions in the right-hand direction, with the rotational speed decreasing with height.

Near the cusp top, we find a transverse oscillation of the surge, with the period of ~2 min. There is no change of the oscillation phase below the cusp top, but above the top a phase change is identified, giving a vertical phase speed about 86kms-1. As the height increases, the initial amplitude of the oscillation increases, and the oscillation damping time decreases from 5.13 to 1.18min. We conclude that the oscillation is a propagating kink wave that is possibly excited by an x-point oscillation.

[구 SS-14] A Comprehensive Study of Interaction of Magnetic Flux Ropes Leading to Solar Eruption

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Solar observations often show that interaction of more than one flux rope is involved in solar eruptions. In this regard, Lau and Finn (1996) intensively studied the interaction of two flux ropes, which reside in between two parallel planes each mimicking one polarity region of the solar photosphere. However, this geometry is quite far from the real solar situation, in which all feet of flux tubes are rooted in one surface only. In this paper, we study the interaction of two flux ropes in a semi-infinite region above a plane representing the solar photosphere. Four cases of the flux rope interaction are investigated in our MHD simulation study: (1) parallel axial fields and parallel axial currents (co-helicity), (2) antiparallel axial fields and parallel axial currents (counter-helicity), (3) parallel axial fields and antiparallel axial currents (counter-helicity), and (4) antiparallel axial fields and antiparallel axial currents (co-helicity). Each case consists of four or six subcases according to the background field direction relative to the flux ropes and the relative positions of the flux rope footpoints. In our simulations, all the cases eventually show eruptive behaviors, but their degree of explosiveness and field topological evolutions are quite different. We construct artificial emission measure maps based on the simulations and compare them with images of CME observations, which provides us with information on what field configurations may generate certain eruption features.

[구 SS-15] Denoise of Astronomical Images with Deep Learning

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Removing noise which occurs inevitably when taking image data has been a big concern. There is a way to raise signal-to-noise ratio and it is regarded as the only way, image stacking. Image stacking is averaging or just adding all pixel values of multiple pictures taken of a specific area. Its performance and reliability are unquestioned, but its weaknesses are also evident. Object with fast proper motion can be vanished, and most of all, it takes too long time. So if we can handle single shot image well and achieve similar performance, we can overcome those weaknesses.

Recent developments in deep learning have enabled things that were not possible with former algorithm-based programming. One of the things is generating data with more information from data with less information. As a part of that, we reproduced stacked image from single shot image using a kind of deep learning, conditional generative adversarial network (cGAN). r-band camcol2 south data were used from SDSS Stripe 82 data. From all fields, image data which is stacked with only 22 individual images and, as a pair of stacked image, single pass data which were included in all stacked image were used. All used fields are cut in 128x128 pixel size, so total number of image is 17930. 14234 pairs of all images were used for training cGAN and 3696 pairs were used for verify the result.

As a result, RMS error of pixel values between generated data from the best condition and target data were 7.67×10^{-4} compared to original input data, 1.24×10^{-3}. We also applied to a few test galaxy images and generated images were similar to stacked images qualitatively compared to other de-noising methods. In addition, with photometry, The number count of stacked-cGAN matched sources is larger than that of single pass-stacked one, especially for fainter objects. Also, magnitude completeness became better in fainter objects. With this work, it is possible to observe reliably 1

magnitude fainter object.

[구 SS-16] Possible Causes for the Temporal Variations of 3-micron Hydrocarbon Emissions in the Auroral Regions of Jupiter

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Recently, temporal variations of the 3-micron emissions of methane and ethane have been detected in the auroral regions of Jupiter observed from Gemini North (Kim et al. 2019, in preparation). These temporal variations of 3-micron hydrocarbon emissions in the auroral regions can be caused by the following phenomena: temporal variations of temperatures, mixing ratios, auroral particle bombardments and Joule heatings, and the combinations of these. Although we are not able to quantitatively determine the cause of the temporal variations at this moment, we will present the following quantitative discussions: thermal influences on the 3-micron emissions, global mixing ratio distributions of the hydrocarbon molecules, and energy distributions of auroral particles penetrating the hydrocarbon layers. We will also present a possible correlation between the temporal variations of the 3-micron emissions and solar wind activities.

[구 SS-17] Polarimetry of the Moon through the eyes of PolCam: Phase-angle coverage

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한국형 시험용 달 궤도선(KPLO)에 실릴 과학 탑재체 가운데 하나인 광시야 편광 카메라(PolCam)는 최초로 달 표면 전체의 편광 특성을 관측한다. 편광 특성은 태양-달-관측기기 사이의 각도인 위상각에 따라 달라지므로, 다양한 위상각에서의 반복 관측을 통해 달 전 지역에 대한 각각의 편광곡선을 얻을 예정이다. 편광곡선으로부터 달 표면의 입자 크기와 성분 등의 분포를 알 수 있다. 이는 과학적으로도 흥미로울 뿐 아니라, 미래의 달 탐사 임무를 위한 착륙지 선정 시에도 중요한 참고자료가 된다. 여기에서는, PolCam이 1년간의 KPLO 임무 동안 관측할 수 있는 지역 및 위상각의 분포를 소개한다. 또한, 임무 도중 관측이 일시중지되거나 임무 자체가 비정상종료되는 경우 불완전한 관측 자료로부터 편광곡선을 구하는 방법에 대해 알아본다.

[구 SS-18] KARI Planetary Data System for Science Research Support in Korea Pathfinder Lunar Orbiter Program

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우리나라 최초의 우주탐사 프로그램인 Korea Pathfinder Lunar Orbiter (KPLO)는 1년의 임무기간동안 달과 달 주변의 우주환경에 대한 과학탐사 임무를 수행할 예정이다. 이를 위해서 1개에 기술 검증장비와 고해상도 카메라를 포함한 5개의 과학장비를 탑재할 예정이다. 이 중 고해상도 카메라인 LUTI(LUnar Terrain Imager)와 국내에서 개발한 3개의 과학탑재체(KGRS;감마선분광기, KMAG;자기장측정기, PolCam;광시야 편광카메라)가 획득한 과학자료는 일정기간(통상 1년)동안 비공개로 검보정이 이루어진 후 일반에게 공개(Public release)할 예정이다. 이러한 과학자료의 공개와 관리를 위해서 한국항공우주연구원은 KPLO 심우주 지상시스템 내에 과학자료의 공개 및 관리를 위한 KARI Planetary Data System(KPDS)을 개발하고 있다. KPDS는 미국 NASA의 PDS에서 개발하여 유럽, 일본 등에서 이미 행성탐사 과학자료의 표준으로 활용하고 있는 PDS4 표준을 준수하는 과학자료를 제공할 것이다. 본 발표를 통해서 KPDS의 운영개념과 과학자료 관리계획, 그리고 KPDS의 개발현황을 천문학계와 공유하여 KPLO에 의해서 획득된 과학자료가 많은 과학자들이 활용하여 높은 과학적 성과를 낼 수 있기를 기대한다.

우주론

[구 CD-01] Second order induced gravitational waves

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We present the second order solutions of the cosmological gravitational waves induced by linear cosmological perturbations.

[구 CD-02] Formation of First Astrophysical Objects under the Influence of Large-Scale Density and Velocity Environment

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We present our first attempt at understanding the dual impact of the large-scale density and velocity environment on the formation of very first astrophysical objects in the Universe. Following the recently developed quasi-linear perturbation theory on this effect, we introduce the publicly